Draft Statewide River, Miss. Pool & Pepin Eutrophication Criteria

as presented to

Mississippi River Forum

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Minnesota Pollution Control Agency

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Outline

- Statewide River Eutrophication Criteria
- Linkage with Lake Pepin & Mississippi River navigational pool eutrophication criteria;
- Challenges in Applying the Criteria
- Summary & Timelines




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Need for River Nutrient Standards

- Nutrient enrichment negatively impacts aquatic biota and recreation
- USEPA – States should develop nutrient criteria for lakes, streams, wetlands (must develop may be more accurate based on recent Florida & Wisconsin case)
- MN promulgated ecoregion-based lake eutrophication standards in 2008
- MN will promulgate river eutrophication standards in the 2010-2012 rulemaking

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Statewide river criteria development

- Document relationships among nutrients, suspended algae, BOD, diurnal DO flux (daily max DO-min DO), fish, & inverts;
- Identify threshold concentrations;
- Assign numeric criteria based on above & supporting information;
- Numeric translator to address excess attached algae (periphyton);
- Adopt criteria into Minnesota's water quality (Ch. 7050) standards

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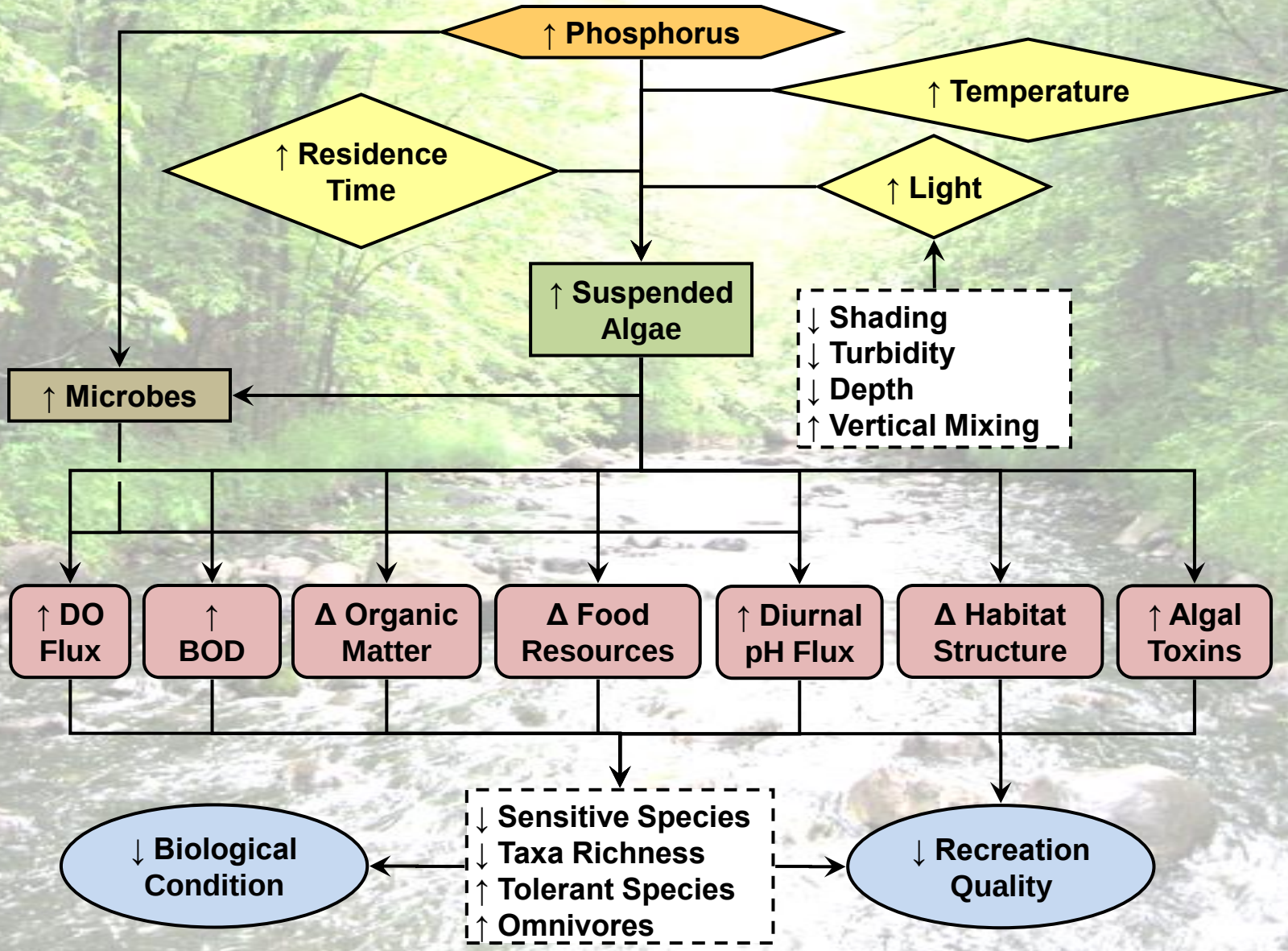
Draft river eutrophication criteria (summer-means)

	Nutrient	Response		
Region	**TP µg/L**	**Chl-a µg/L**	**DO flux mg/L**	**BOD_5 mg/L**
North	**55**	**<10**	**≤4.0**	**≤1.5**
Central	**100**	**<20**	**≤4.5**	**≤2.0**
South	**150**	**<40**	**≤5.0**	**<3.5**

Ecoregion-based eutrophication criteria for nutrient (TP) and response variables: sestonic chlorophyll-a, daily dissolved oxygen flux (change) & biochemical oxygen demand;
pH >9.0 (WQS) can be used as a response variable as well;

Conceptual model on impact of nutrient enrichment on biological condition and recreational quality for medium to large rivers



River Nutrient Study studies & data collection

Probe for continuous DO measurement

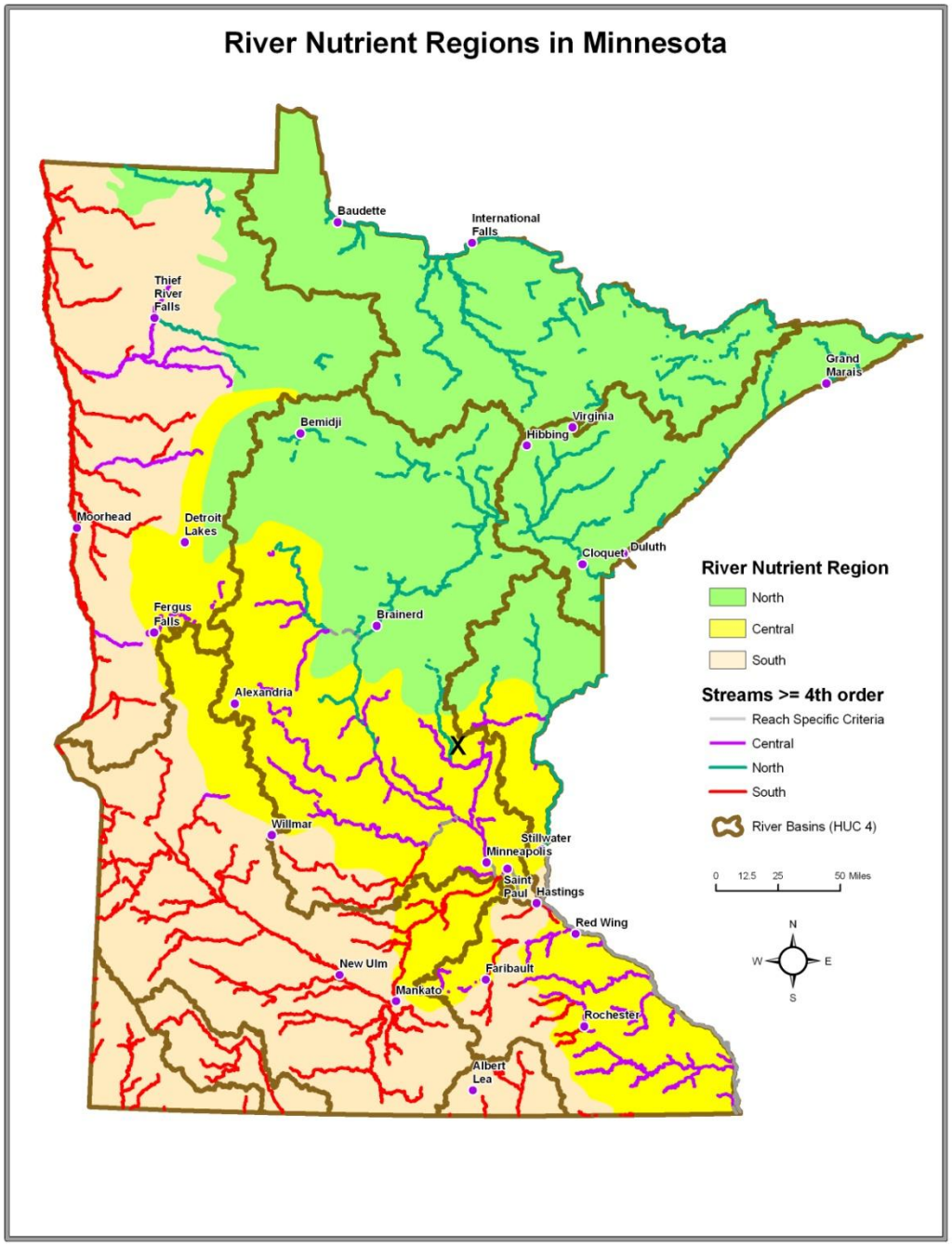
- **1999 & 2000 - Initial EPA-funded studies focused on representative medium-large rivers in various ecoregions - e.g. Crow, Miss. & Rum (below) focus on non-wadeable, watershed area generally>1,000 mi²**
- **2001 – Sampled a range of rivers to test relationships & expand spatial coverage**
- **2006 & 2008 – expanded coverage to all ecoregions**
- **River nutrient dataset ~40 sites w/ nutrients, biology & diurnal measurement.**
- **Later incorporated data from 100's of biological monitoring sites for state-wide coverage both wadeable & non-wadeable;**

South Fork

North Fork

Miss. at Monticello

Rum



River Nutrient Regions (RNR)

Needed to regionalize criteria development because:
1) distinct differences among landform, land use, soil type, & stream water quality in MN &
2) EPA recommendation;
3) Consistent with lake standards

EPA Ecoregion map is the base map;
Rivers classified based on:
- Relative ecoregion composition;
- Review of reach-specific WQ;

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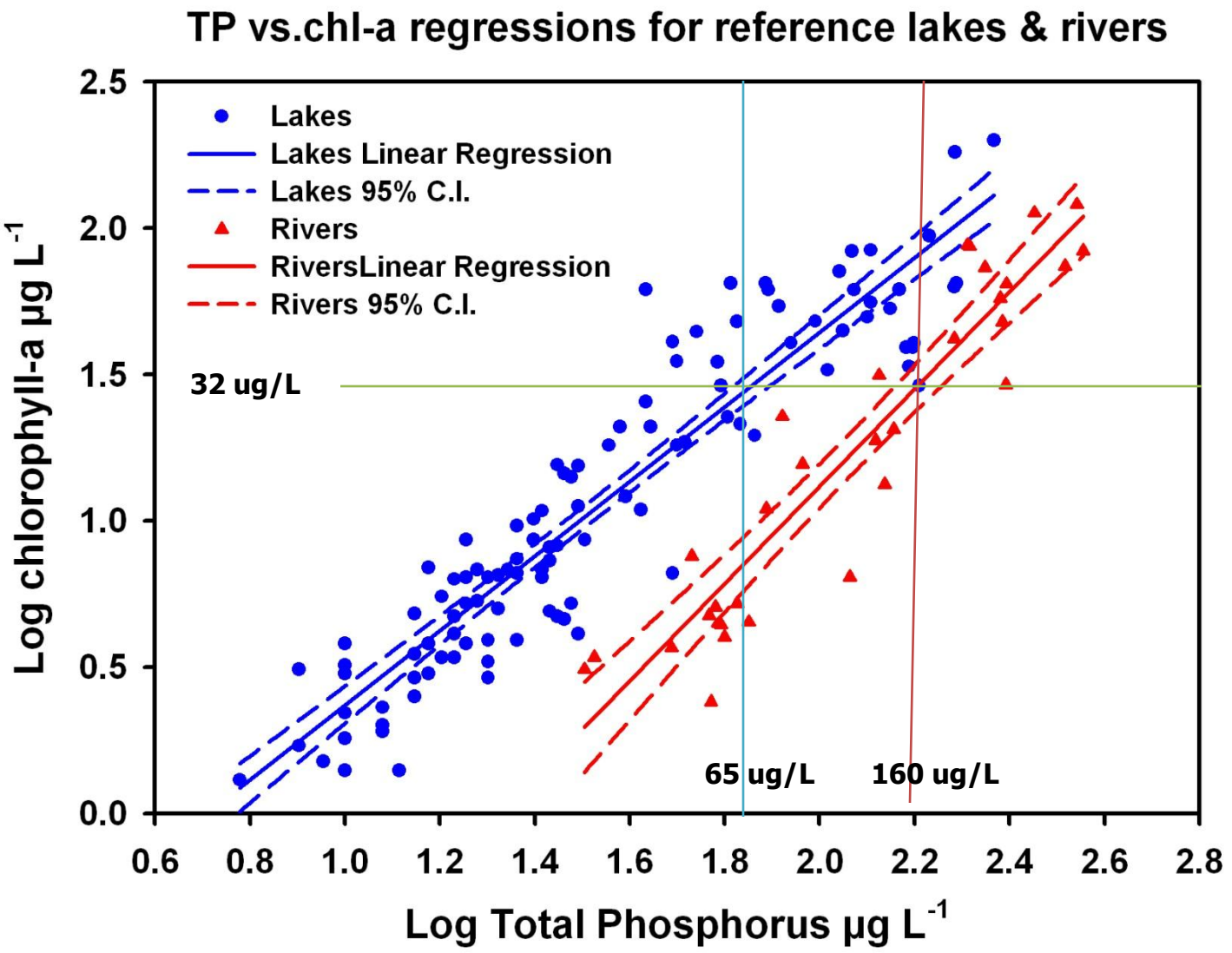
Criteria development: multiple lines of evidence

1. Spearman correlation: initial examination of relationships among TP, TN, Chl-T, DO flux, and biological metrics
2. Linear regression: define relationships among TP, N, Chl-T, and DO flux
3. Scatterplots: visualize relationships among biological metrics and stressors and begin threshold ID
4. Quantile regression and changepoint analysis: threshold concentrations determined for wadeable vs. nonwadeable and on a region-specific basis

- Comprehensive literature review to provide further perspectives
- **Use above to move from broad ranges to region-specific criteria**

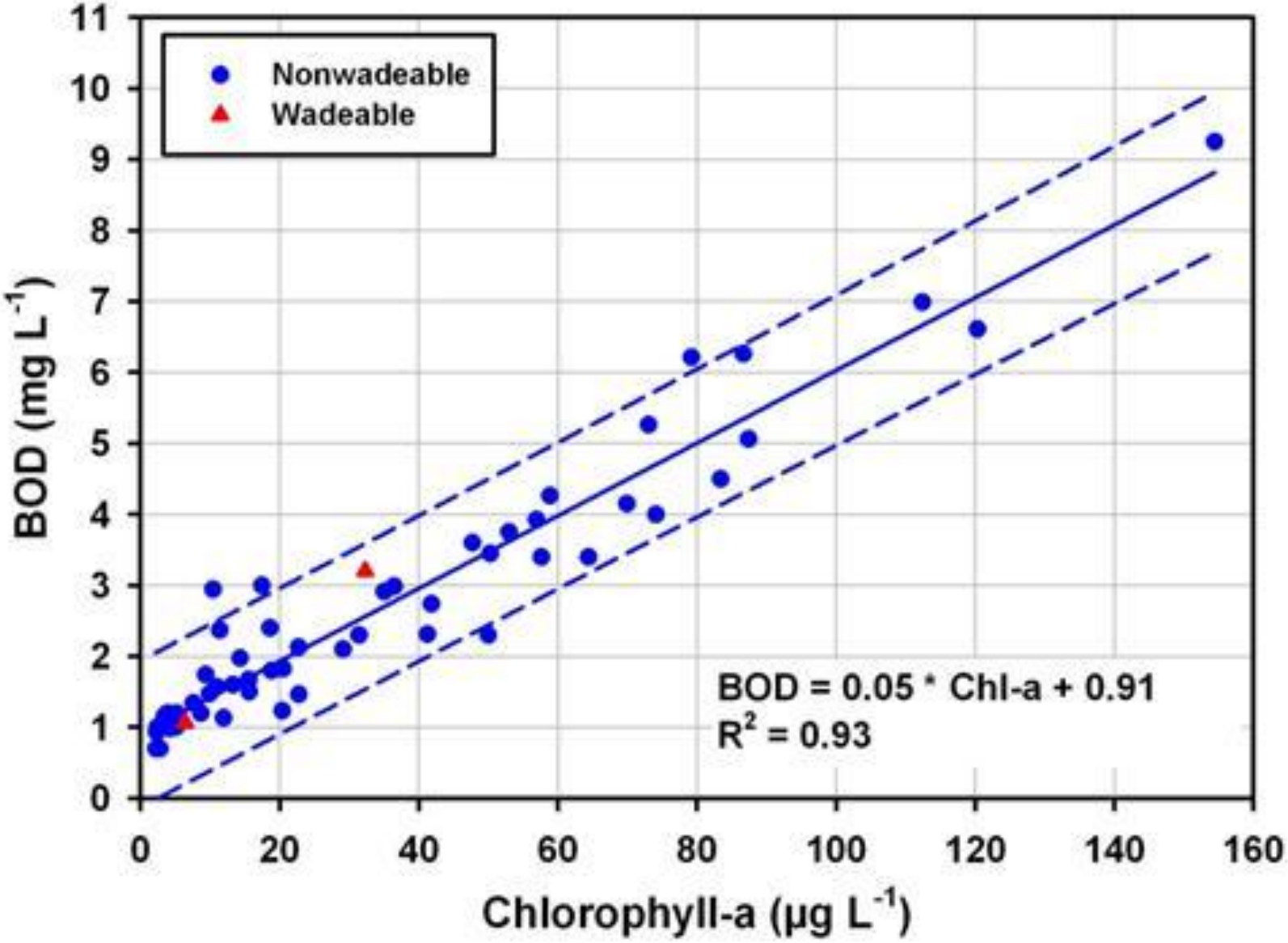


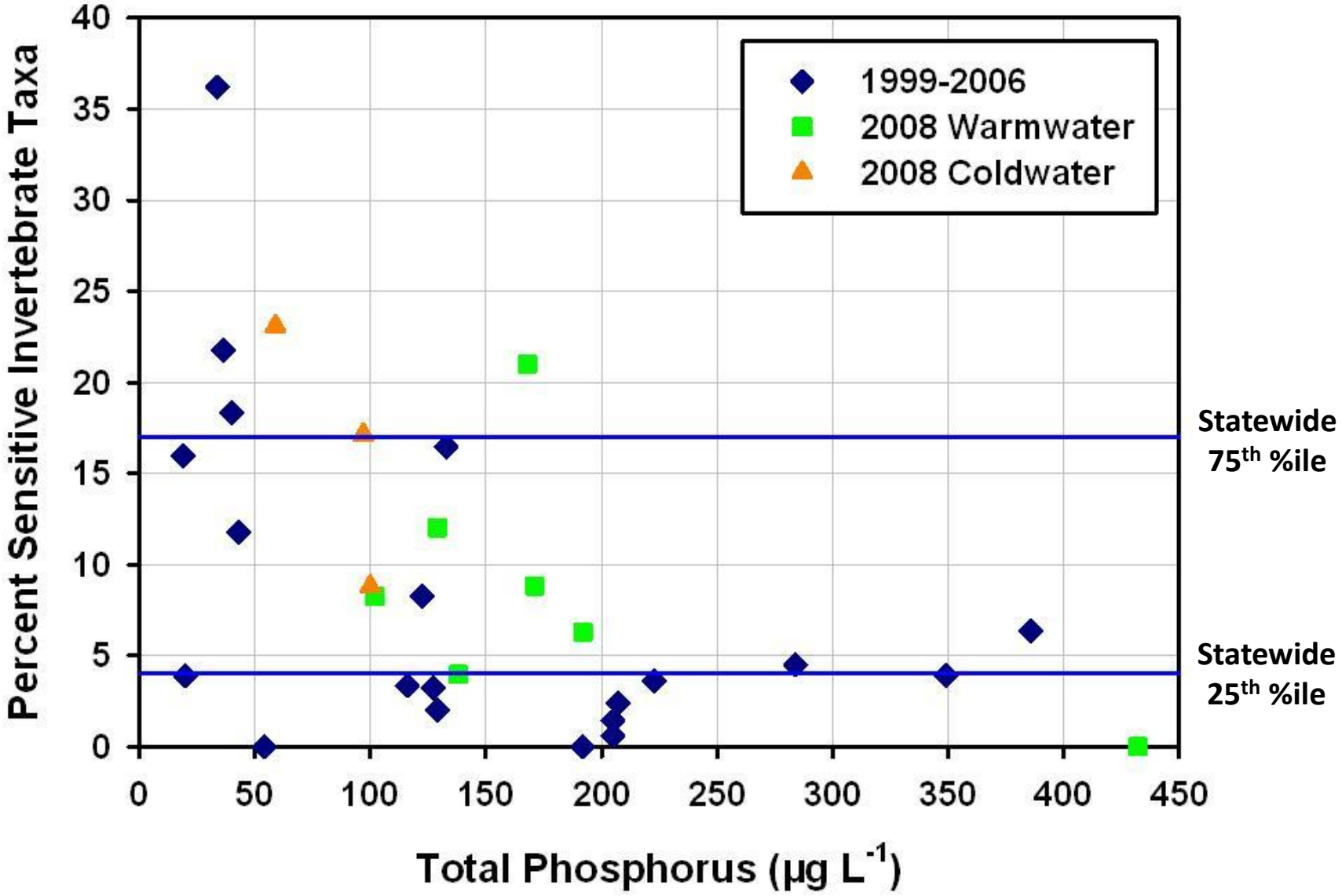
Established relationship among TP & Chl-a based on RN data for 31 rivers.

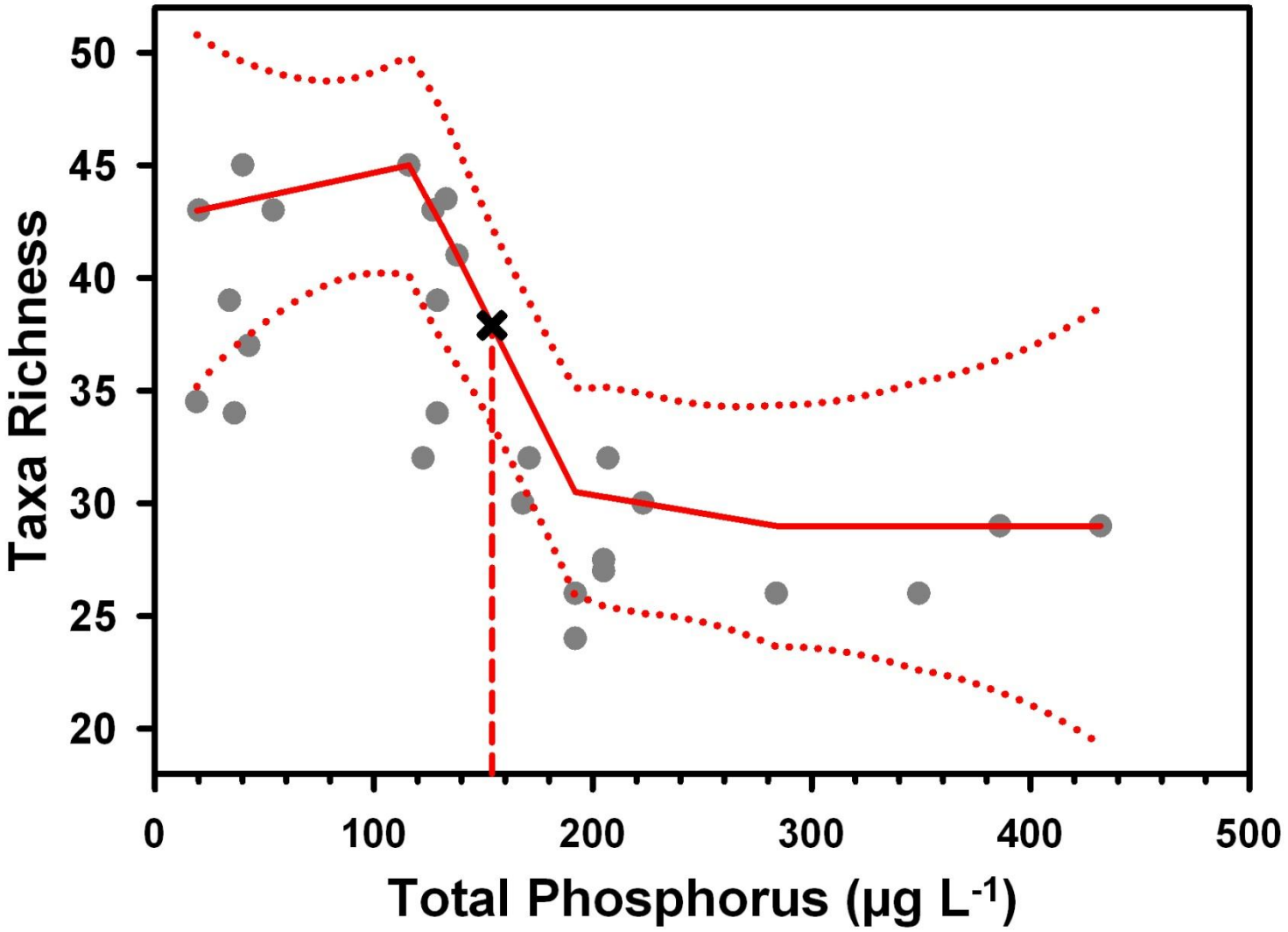
- Different relationship but equally as strong as lakes.
- Stream size, flow & turbidity influence relationships.

River chlorophyll (suspended algae) and BOD



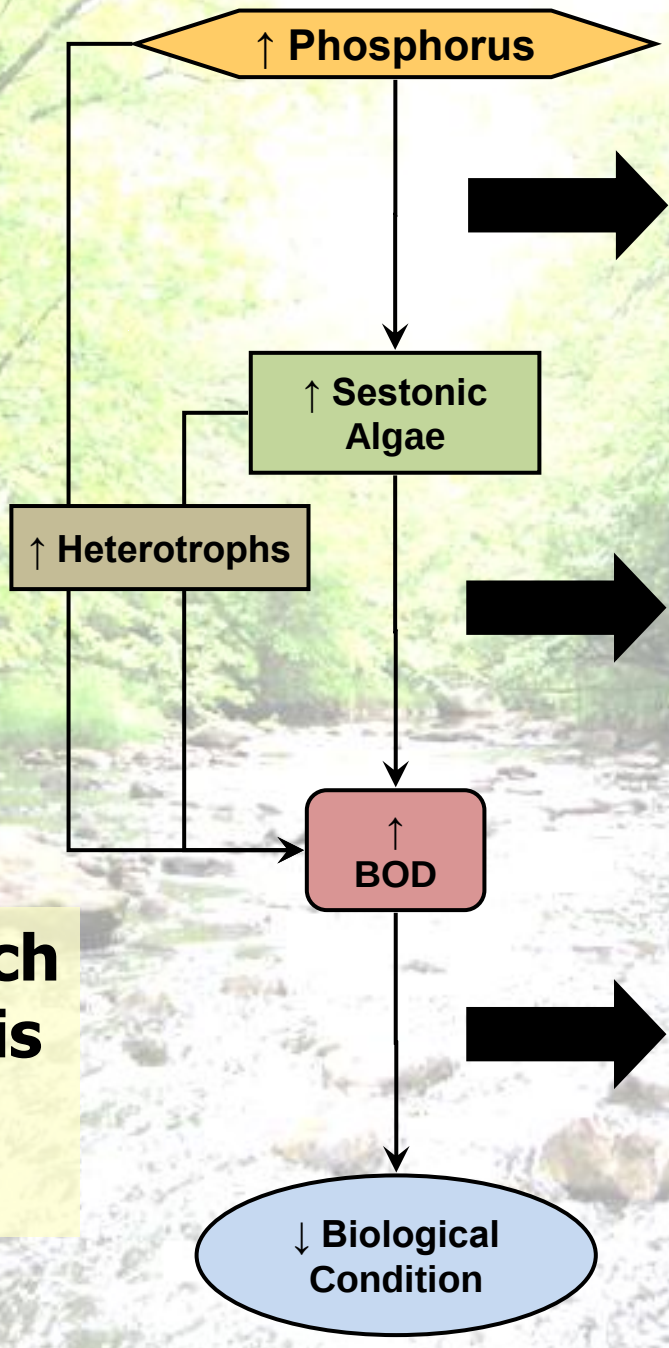
Phosphorus and Aquatic Life

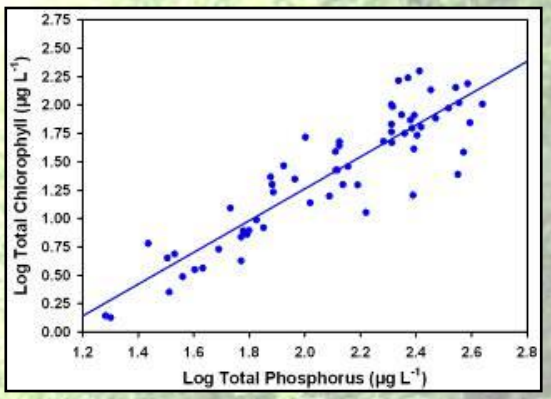


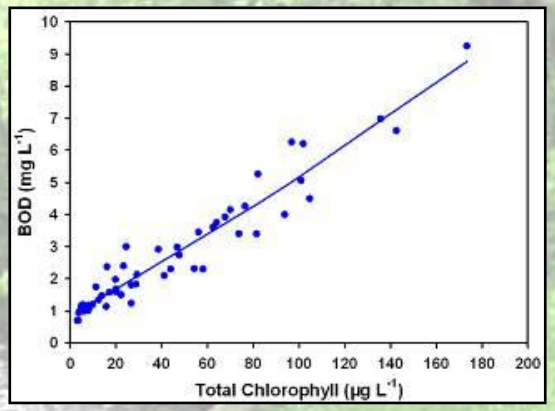


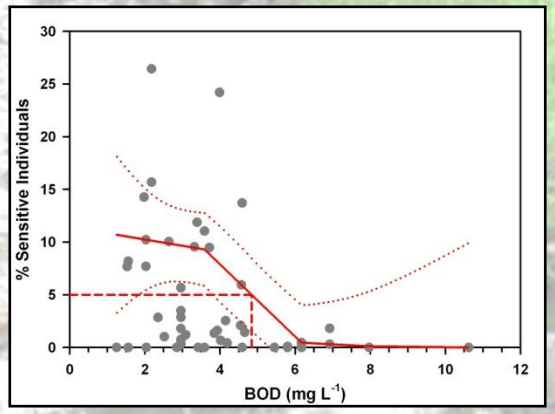
Quantile (piece-wise) regression (with CI) describes relationships & ID threshold concentrations. Mid-point of 2 breakpoints used to interpolate TP.

Conceptual approach & statistical analysis (links stressor to impairment)









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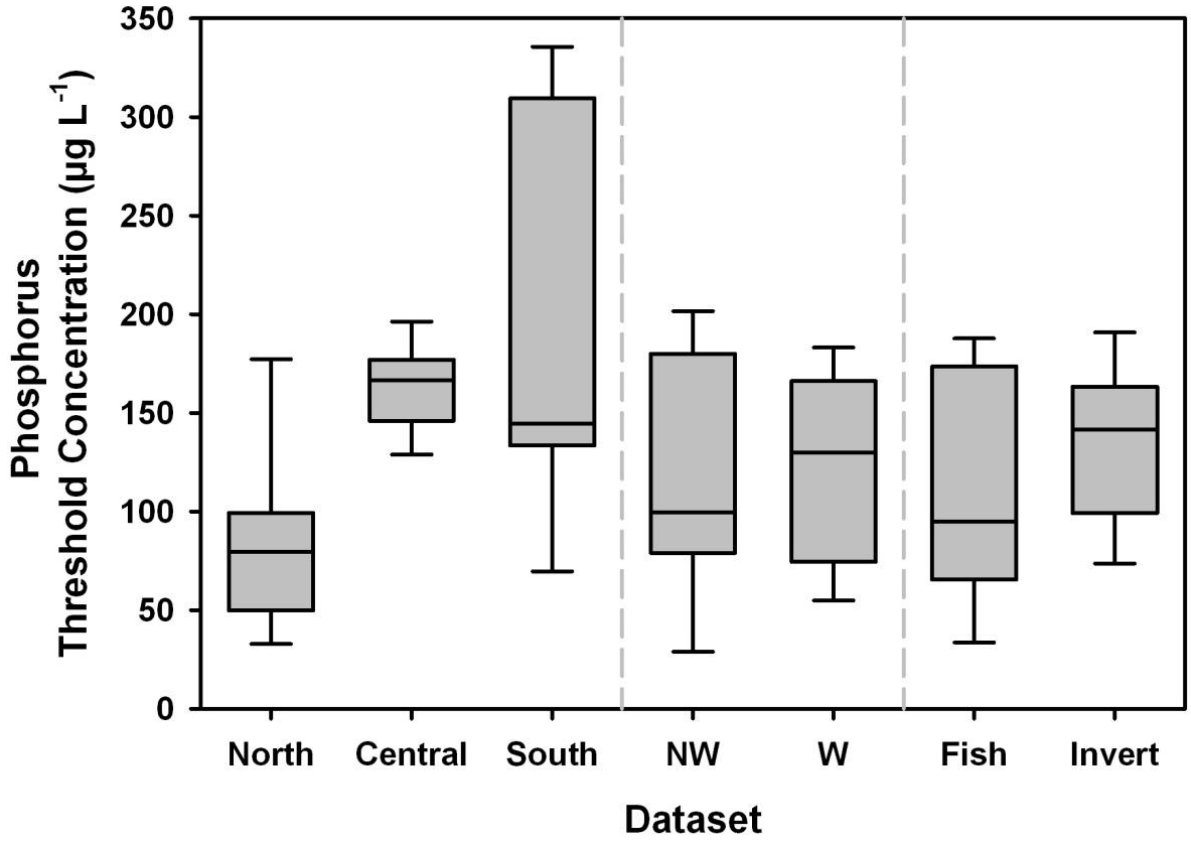
Threshold Concentrations

Threshold concentrations from biological tests for:

- Region: north, central, and south
- River size: nonwadeable and wadeable
- Biological group: Fish and invertebrate



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Draft river eutrophication criteria (summer-means).

	Cause	Response		
Region	**TP µg/L**	**Chl-a µg/L**	**DO flux mg/L**	**BOD_5 mg/L**
North	**55**	**<10**	**≤4.0**	**≤1.5**
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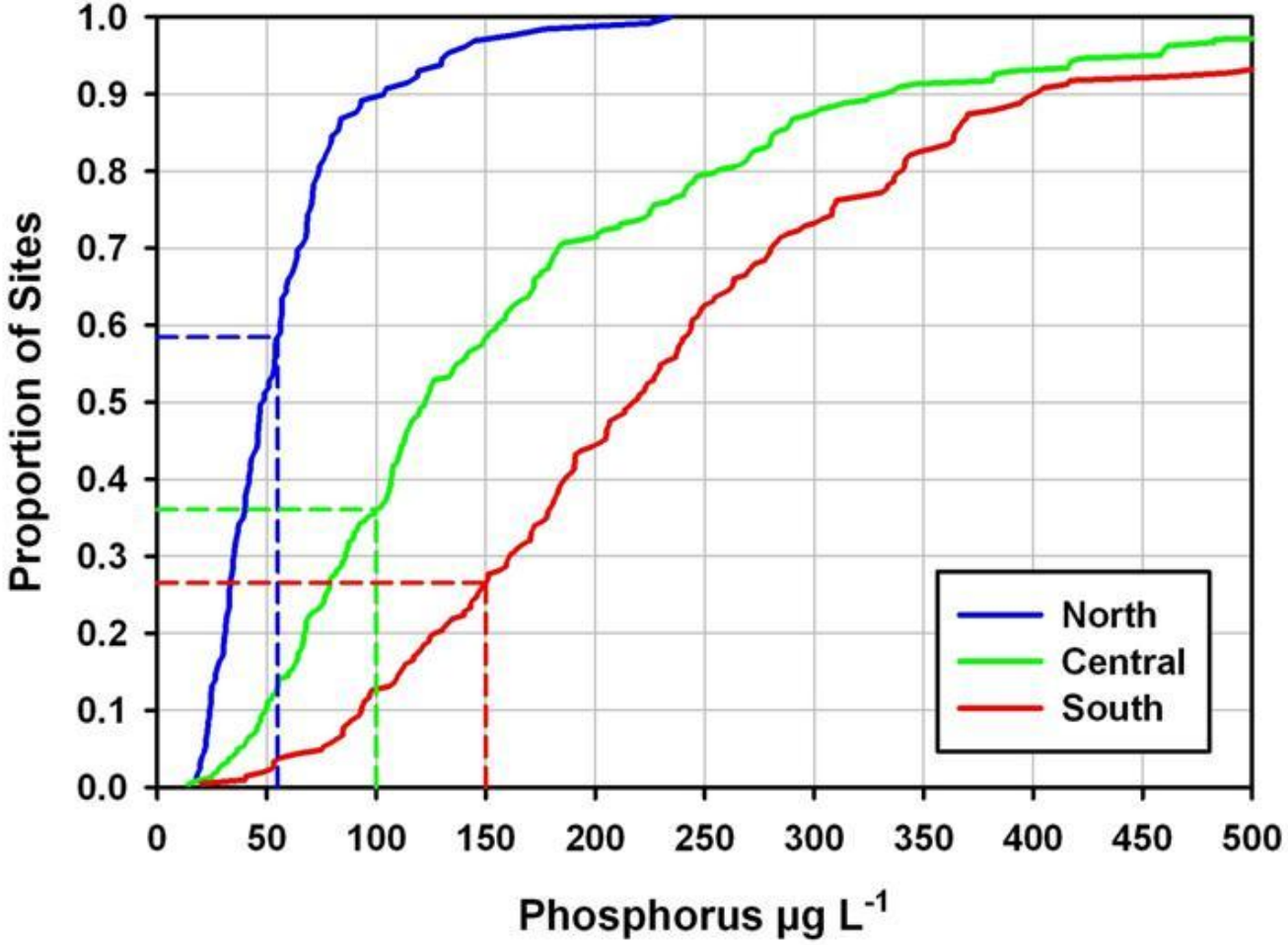
South	**150**	**<40**	**≤5.0**	**<3.5**

- Future assessments based on:
- Minimum of 2 summers & 6 or more obs./summer;
- Data from most recent 10 years;
- Must exceed cause & one or more response (stressors)to be deemed impaired (303(d) listed)

Draft TP criteria compared to RNR-based TP distribution.



Demonstrates distinct regional patterns & relative comparison of criteria to regional TP distributions. Based on summer-mean STORET data from 1995-2009 for 128 (North), 239 (Central) and 209 (South) river sites.

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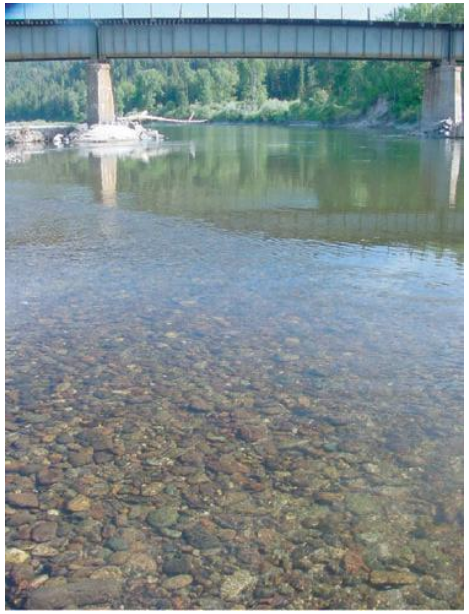
Example assessment based on STORET data for most recent 10 years

Region/River Name	TP ug/L	Chl-a ug/L	BOD mg/L	303(d) list
North RNR	**55**	**10**	**1.5**	
Leech Lake River nr Ball Club	28		1.5	N
Pine River nr Mission, CSAH11	28		1.0	N
St. Croix River nr Danbury, WI	39	3	1.0	N
Mississippi River at Aitkin, MN	52	6	1.2	N
Kettle River nr Sandstone, MN	57	3	1.0	close
Central RNR	**100**	**20**	**2.0**	
Leaf River nr Staples, CSAH29	84	3	1.2	N
Sauk River nr St. Cloud, MN	172	25	2.6	Y
North Fork Crow River nr Rockford	253	56	3.5	Y
Cannon River at Welch, MN	190	16	2.6	Y
Mississippi River at Anoka	88	23	1.8	close
Rum River at St. Francis	125	19	1.9	close
South RNR	**150**	**40**	**3.5**	
South Fork Crow River at Delano	395	102	7.9	Y

Addressing excess <u>attached</u> algae:

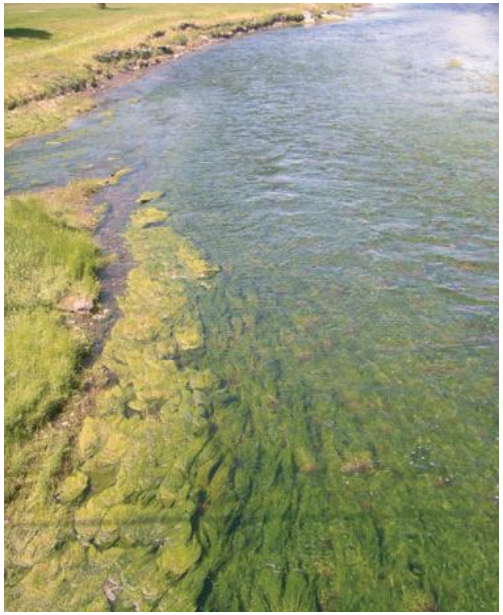
Periphyton Chl-a <150 mg/m^2 (mass/unit area)

- Current scientific literature suggests a biomass concentration of 150 mg CHL *a/m^2* protects streams' beneficial uses and higher biomass is considered polluted with loss of uses.
- This is a numeric translator of the general narrative WQS language that does not allow "noxious growth of algae."
- Because it is a translator, there are no nutrient concentrations associated with this biomass WQS (requires stressor ID to determine causation).



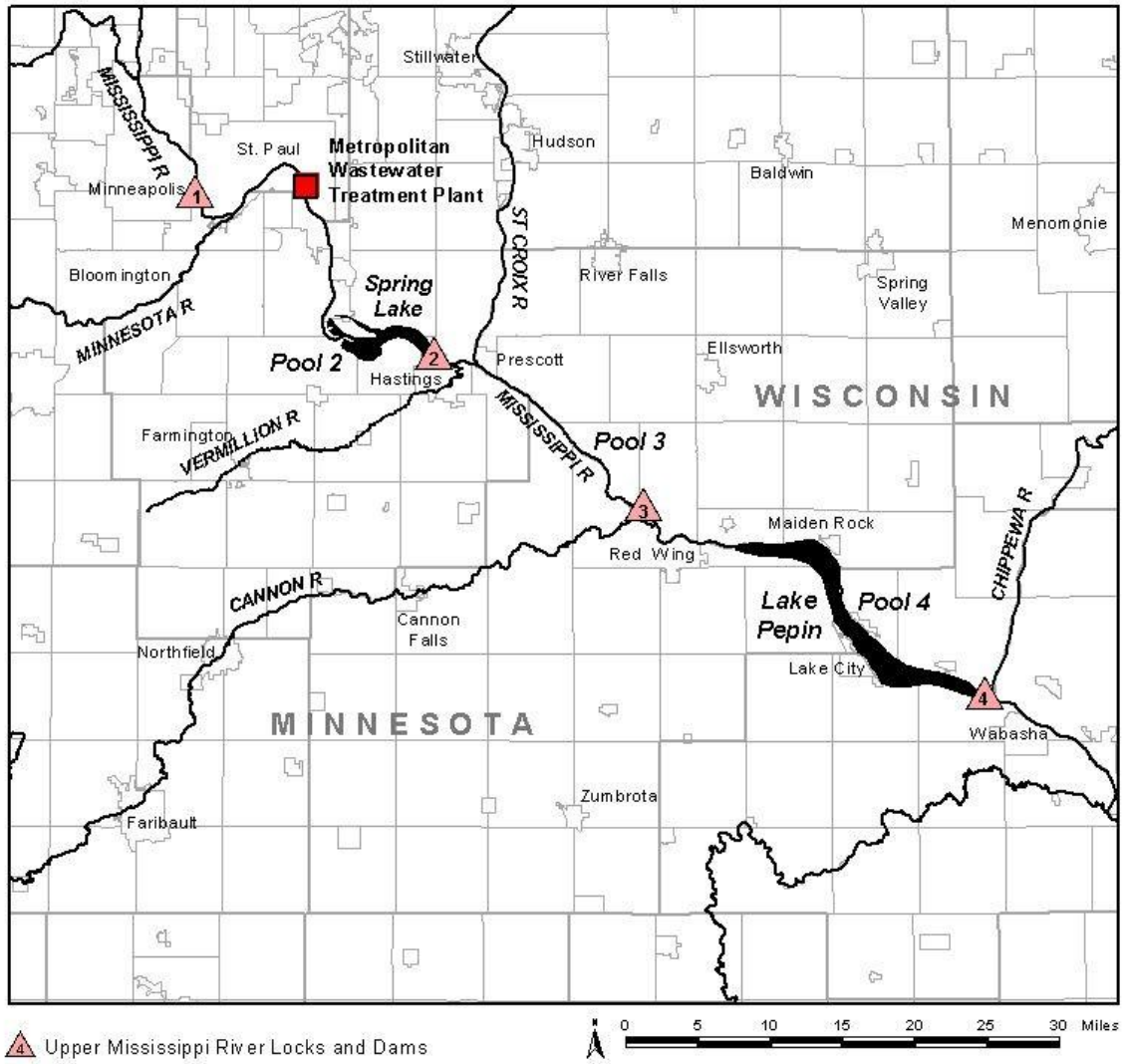
Low

~150 mg/m2



>150 mg/m2

Linking statewide river criteria with Lake Pepin & Miss. River navigational pool criteria



Lake Pepin Draft Eutrophication Criteria

Criteria & Considerations: TP = 100 ug/L

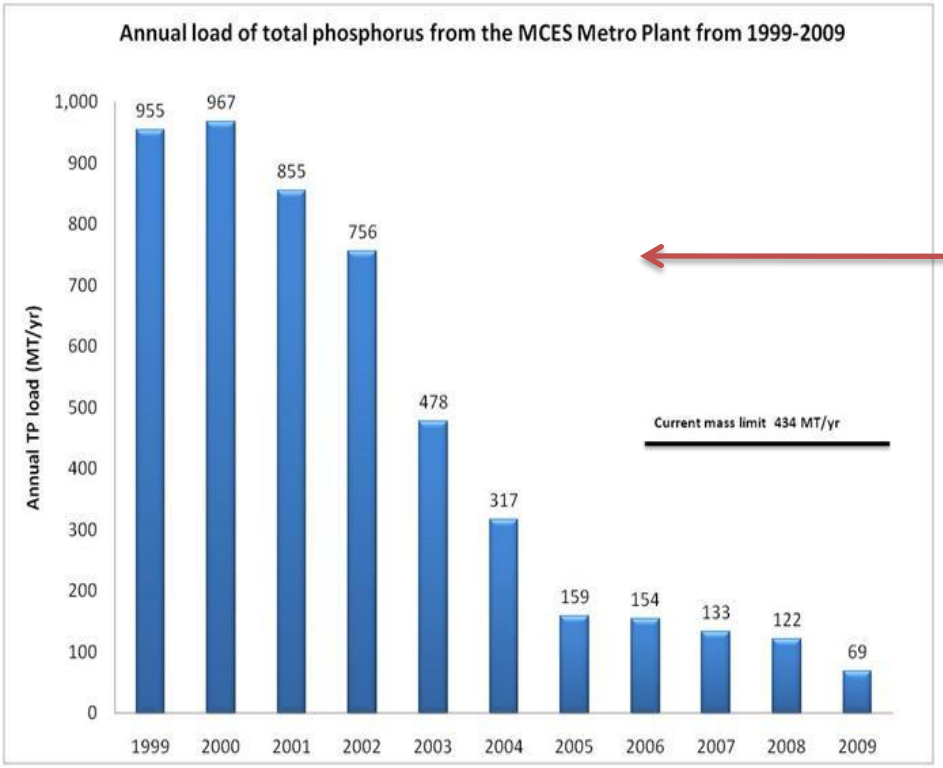
- Lower end of TP range for 1900-1960 time period;
- Supported by modeling
- Consistent with WI standard;
- Consistent with MN river standards;

Criteria & Considerations: Chl-a = 28 ug/L

- Keep frequency of nuisance blooms (>50 ppb) to < 5% summer;
- Minimize dominance of blue-greens;

Reductions needed to meet Pepin criteria (modeled):

- 50% reduction in Minn. & Cannon River TP & Chl-a;
- 20% reduction in Miss. & St. Croix Rivers TP & Chl-a;
- Reductions needed from point & nonpoint sources, good progress to date at MCES Metro facility;



Example of a major reduction in P loading

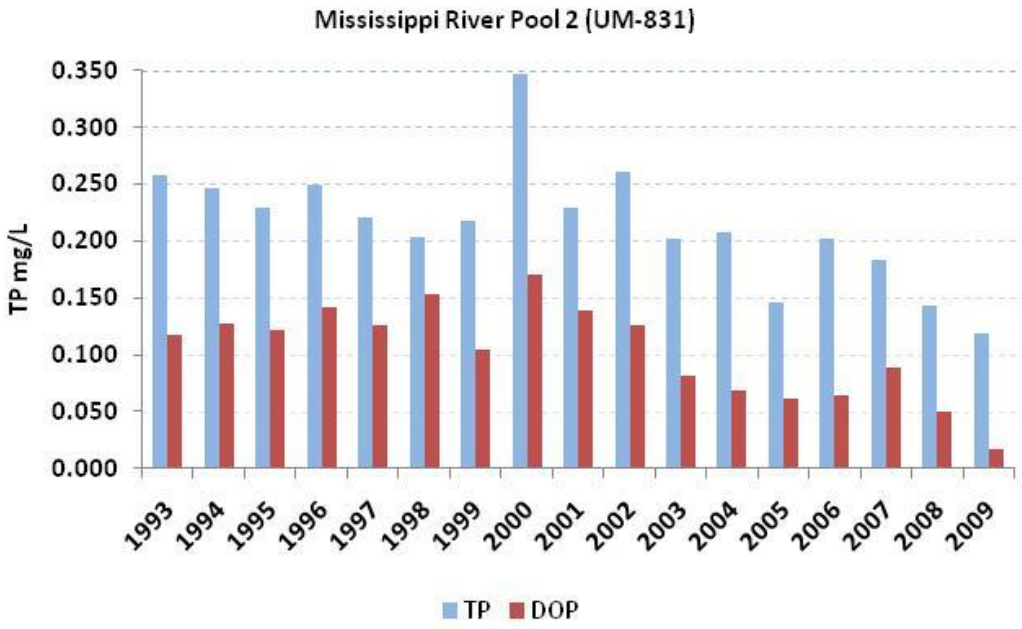
MCES Metro Plant P loading: 1999-2009

- Effluent reduced from ~3 mg/L to <0.5 mg/L by 2005;

Pools 2 & 3 TP:1993-2009

- Recent TP in Pools 2 & 3 <150 ug/L
- Evidence of periodic P limitation

Pool 2 near Hastings



Draft criteria for main-stem rivers, Mississippi R. pools & Lake Pepin.

Concentrations expressed as summer averages.

River/Pool	Site (RM)	Data source	TP µg/L	Chl-a µg/L
Miss. @Anoka[1]	UM-872	MCES	**100**	**20**
Pool 1[2]	UM-847	MCES	**100**	**35**
Lake St. Croix[3]		MCES	**40**	**14**
Minn. @Jordan[1]	MI-39	MCES	**150**	**40**
Pools 2-3[4]	UM-815	MCES	**--**	**35**
Pepin[5]	4 fixed sites	LTRMP	**100**	**28**
Pools 5-8[6]	Near-dam	LTRMP	**--**	**35**

[1] Statewide river eutrophication criteria-based.

[2] Minimize frequency of severe blooms; Upstream criteria protect Pool 1.

[3] MN lake criteria-based.

[4] Minimize frequency of blooms & support Pepin requirements

[5.] Lake Pepin criteria based on mean from 4 sites.

[6] Minimize frequency of severe blooms; upstream P requirements benefit lower pools.

WI standard of 100 µg/L TP may apply to Pools 5-8 & inflowing rivers;

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Challenges in Applying Criteria

- Miss. River pool criteria are “system goals” – not always cause-effect between TP and chl-a values at given site.
- Need to find upstream algae “hot spots” & focus TP reductions there:
  - Minn. River, N&S Fork Crow, Sauk, …
- This will be done over time through TMDLs & watershed approach

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Challenges 2

- Criteria designed to protect aquatic life and recreation of entire Mississippi River in Minnesota;
- Steep TP reductions needed upstream of Metro Area to benefit entire system.
- Need to emphasize *targeted reductions* for *system-wide benefits*

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Summary

- Initial draft river criteria revised based on EPA review and comment; re-submitted to EPA August 2010.
- Pepin site specific and pool criteria technical reports also submitted to EPA;
- Linkages among these rivers, pools & Pepin are made & draft criteria reflect interconnectedness and need to protect downstream resources;
- Pepin criteria need be considered in a Miss. R. context & overall approach emphasizes upstream reductions in order to meet criteria and assure uses are met (i.e. not stand-alone goals to be pursued in isolation);

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What's Ahead & Underway

- EPA R5 & HQ review underway;
- Public presentations planned for Nov.;
- Proposed nitrogen criteria based on nitrate-N toxicity, EPA bioassays recently completed
  - Current WQS for 2A & 2Bd 10 mg/L
  - Proposed aquatic life criteria ~5 mg/L
- Complete development of "Statement of Need & Reasonableness (SONAR)" and triennial review process during 2011;
- Finalize by 2012

River Nutrient Reports & Water Quality Rules

MORE INFORMATION:

Water Quality Standards Rule Revision

http://www.pca.state.mn.us/water/standards/rulechange.html

Streams: Algae Monitoring (1 journal article & 2 reports to EPA)

http://www.pca.state.mn.us/water/biomonitoring/bio-streams-algae.html

QUESTIONS/COMMENTS:

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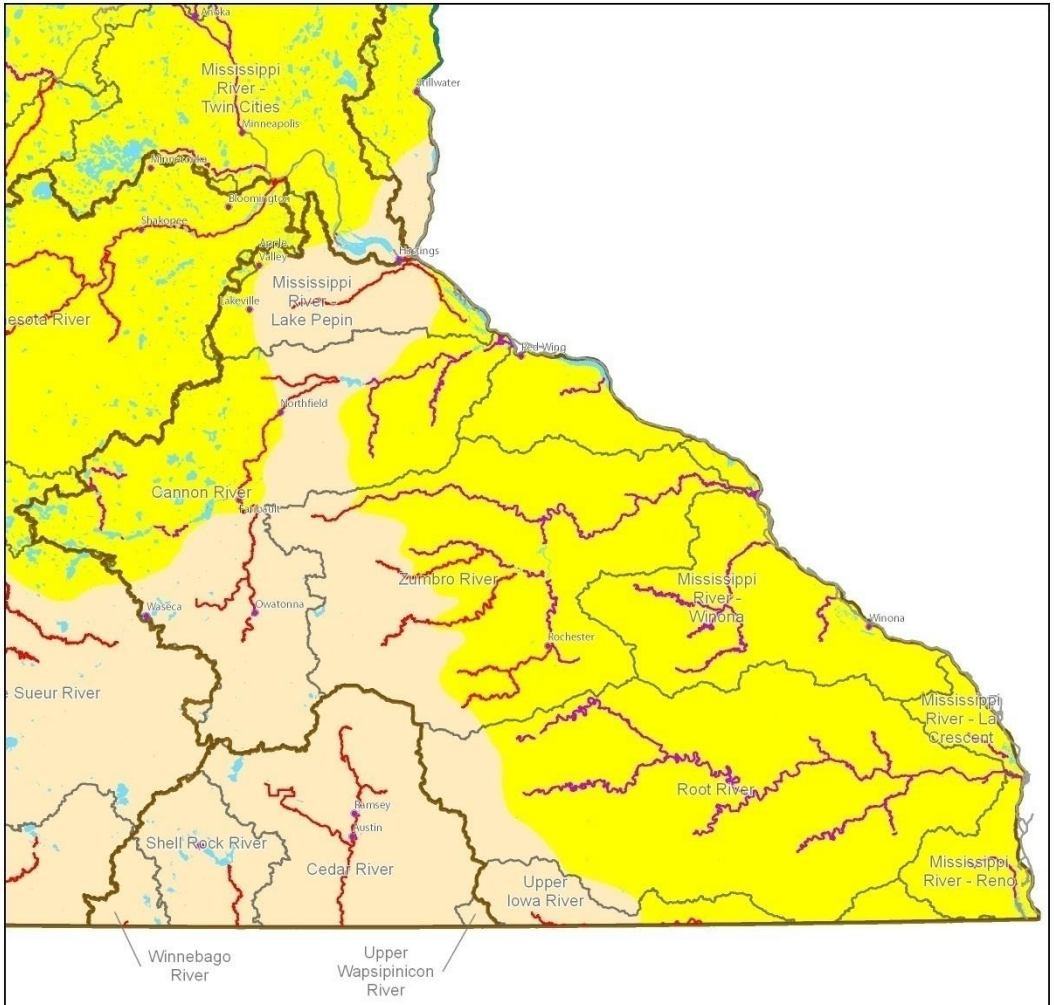
River Nutrient Regions and Stream Assignments

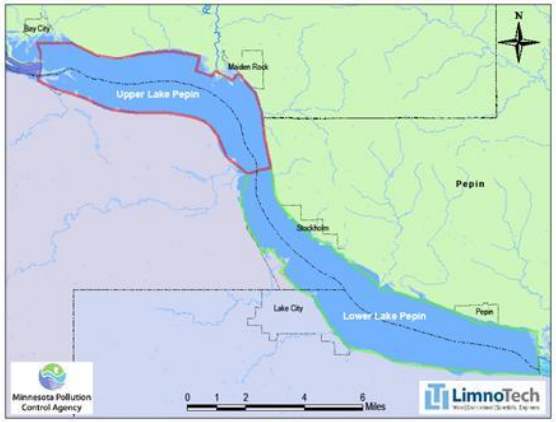


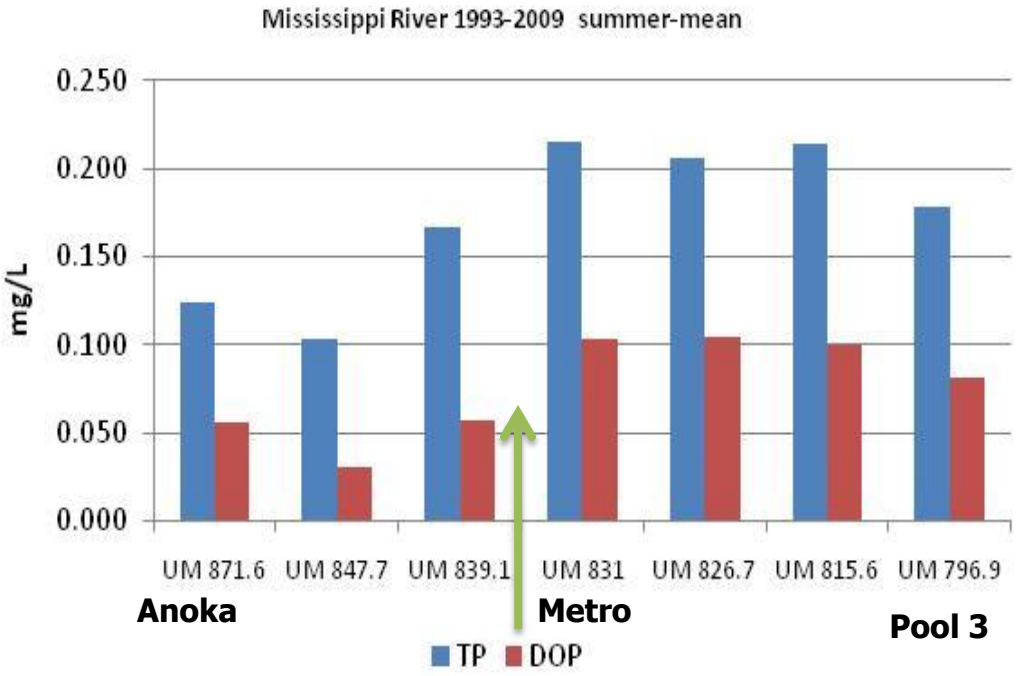
Lake Pepin 303(d) listing, recent range, 2009 and historical values. (MDNR - LTRMP primary source of data)

	2002 303(d) listing ("wet years")	1999-2008 Mean (drier years)	2009 means	Sediment diatom-inferred P from c1900-1960 [4]
TP ppb	198	171	152	~110-140
Chl-a ppb	25	30	32	--

Basis & factors used to develop Pepin TP & Chl-a standards

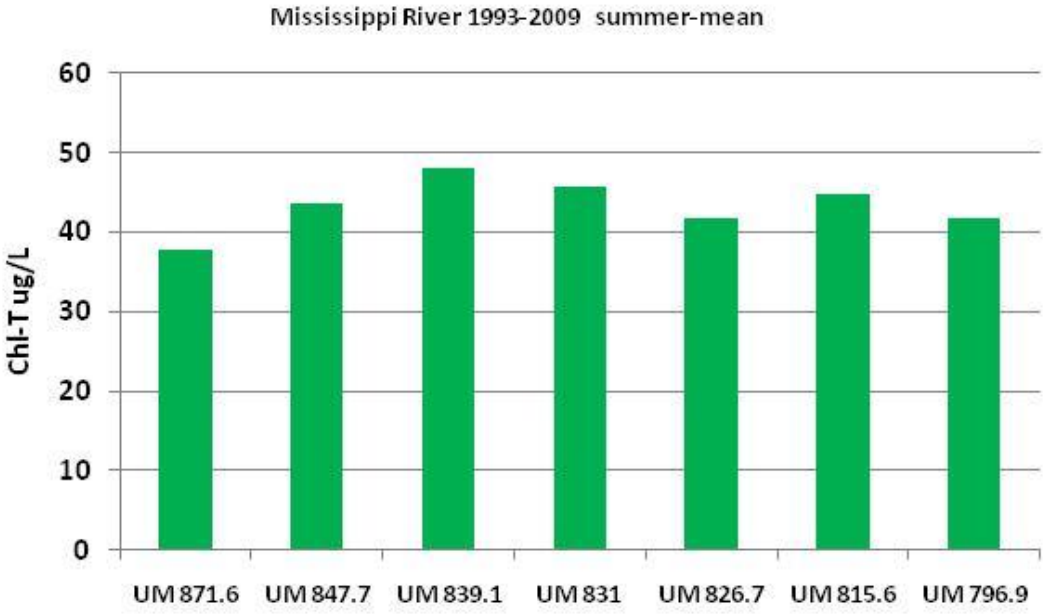
- UMR-LP model projections based on 1985-2006 data + 2007-09 data;
- Sediment diatom reconstructions of in-lake P;
- User perception & need to reduce frequency of nuisance blooms;
- Attain & maintain aquatic recreational use;
- Protection of downstream pools 5-8;
- Mesh with MN statewide river standards & WI standards

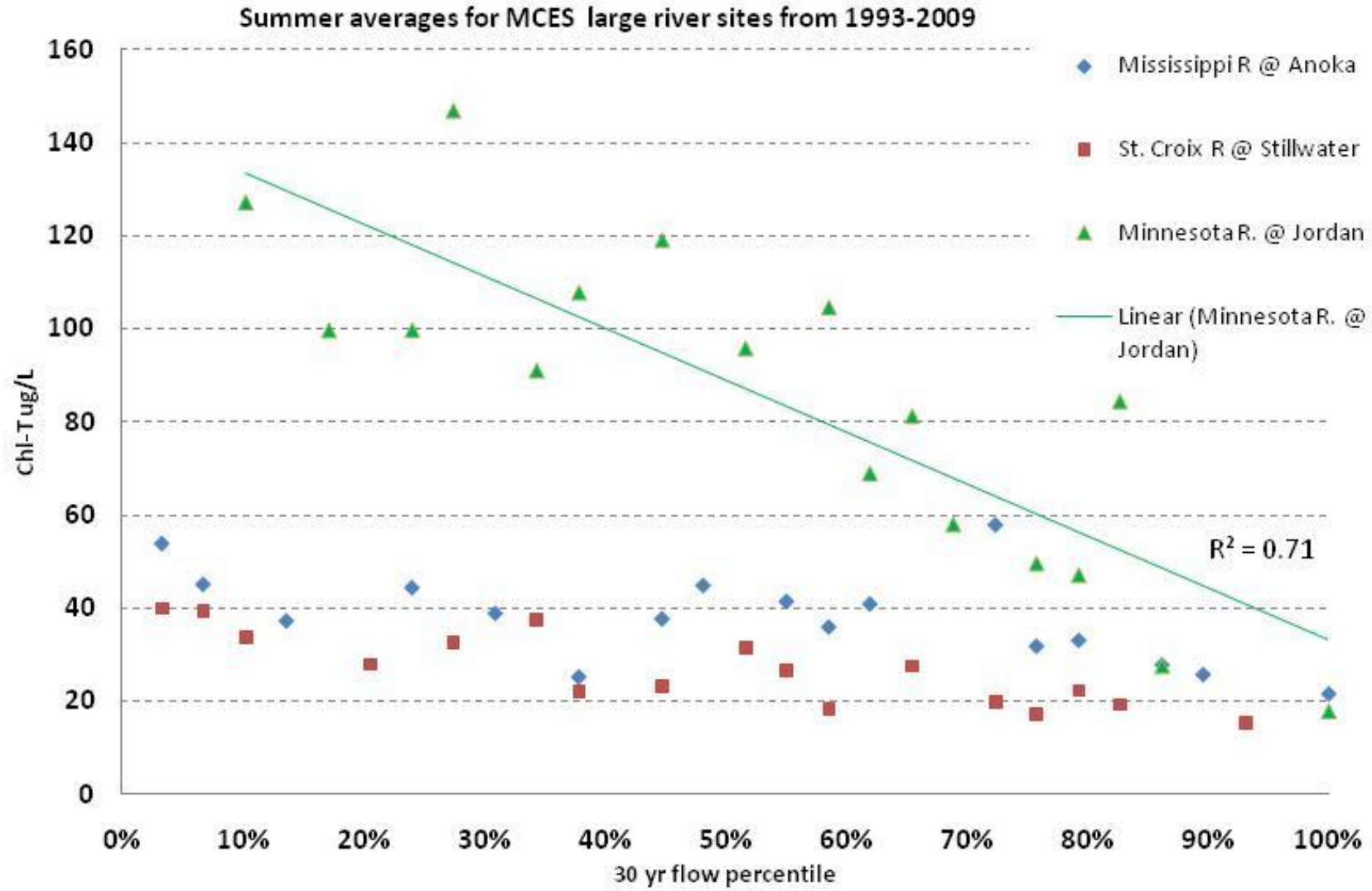




MCES data for rivers & Pools 1-3: <u>1993-2009</u>

- **High upstream loading of Chl to the system from Miss. and MN Rivers;**
- **Pool 2 increase below MN R. inflow**
- **Flow moderates Chl-a production**





2009 **1993**

Chl-a remains high & is a direct function of flow.